Exhibit 9

Waste Burial in Arid Environments—Application of Information From a Field Laboratory in the Mojave Desert, Southern Nevada

USGS

U.S. Department of the Interior—U.S. Geological Survey

Accumulation and management of waste is a pressing problem facing the United States today. Improper disposal of hazardous wastes poses a threat to public health and environmental quality. As arid sites increasingly are being sought for disposal of the Nation's radioactive and other hazardous wastes, concern about the potential effect of contaminants on water resources in the arid western United States is being raised. In addition, volumes of locally generated municipal and industrial wastes are increasing because of rapid population growth and industrialization of the region.

The suitability of a waste-burial site or landfill is a function of the hydrologic processes that control the near-surface water balance. Precipitation that infiltrates into the surface of a burial trench and does not return to the atmosphere by evapotranspiration from the soil and plants can percolate downward and come in contact with buried waste. Water that contacts the waste can enhance the release of contaminants for subsequent transport by liquid water, water vapor, or other gases.

A prevalent assumption is that little or no precipitation will percolate to buried wastes at an arid site. Thick unsaturated zones, which are common to arid regions, also are thought to slow water movement and minimize the risk of waste migration to the underlying water table. On the basis of these assumptions, reliance is commonly placed on the natural system to isolate contaminants at waste-burial sites in the arid West.

Few data have been available to test the validity of assumptions about the natural soil-water flow systems at arid sites, and even less is known about how the construction of a waste-burial facility alters the natural environment of the site. The lack of data is the result of (1) technical complexity of hydraulic characterization of the dry, stony soils and (2) insufficient field studies that account for the extreme temporal and spatial variations in precipitation, vegetation, and soils in arid regions. In 1976, the U.S. Geological Survey (USGS) began a long-term study at a waste-burial site in the Mojave Desert near Beatty, Nev., to collect the necessary data and evaluate untested assumptions. This fact sheet summarizes the findings of investigations at the site and discusses how this information is important to issues of waste burial in an arid environment.

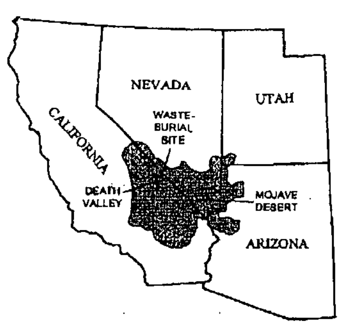

Figure 1. Location of waste-burial site, Death Valley, and Mojave Desert of southwestern United States.

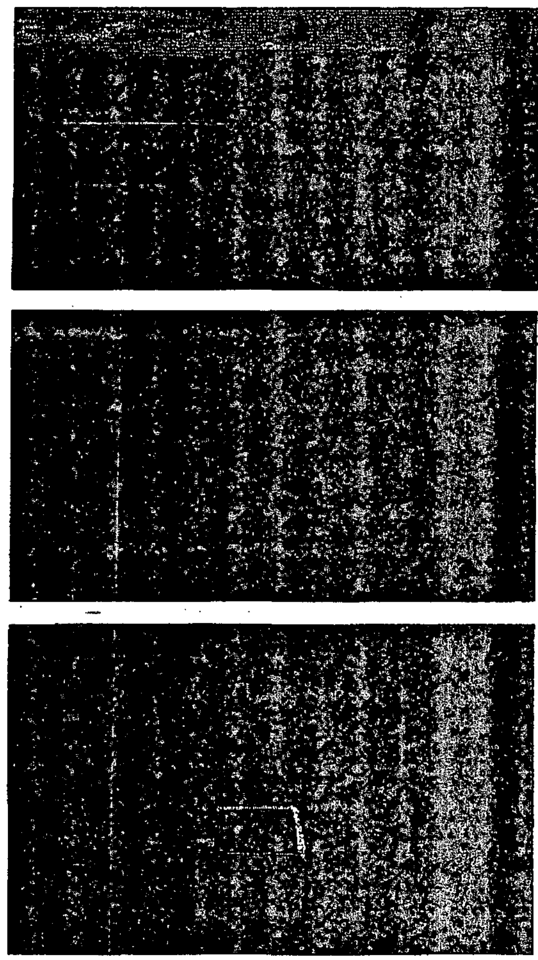

Figure 2. Undisturbed, vegetated area near waste-burial site, October 1991 (*A*); low-level radioactive waste burial trench (*B*); and nonvegetated surface of backfilled waste-burial trench with identifying monument, June 1988 (*C*).

Mojave Desert Waste-Burial Site

The waste-burial site, 30 miles east of Death Valley National Park, is in one of the most arid parts of the United States (fig. 1). Precipitation in the area averages about 4 inches per year. The water table is about 360 feet below land surface. Vegetation in the area is sparse (fig. 2*A*). Burial trenches at the site have been used for disposal of low-level radioactive waste (1962-92) and hazardous-chemical waste (1970-present). Burial-trench construction includes excavation of native soil, emplacement of waste, and backfilling with previously stockpiled soil (fig. 2*B*). The surfaces of completed burial trenches and perimeter areas are kept free of vegetation (fig. 2*C*). Regulations governing burial of low-level radioactive waste do not require that trenches be lined with impervious materials. Prior to 1988, linings were not required for chemical-waste trenches. As a result, only the most recent chemical-waste trench at the site is lined.

Field Laboratory Established

Recognizing the need for long-term data collection, the USGS established a study area adjacent to the waste-burial site through agreements with the Bureau of Land Management and the State of Nevada. This 40-acre area serves as a field laboratory for long-term data collection and the study of hydrologic processes under natural-site and waste-burial conditions.

Lessons Learned to Date

Early (1962) evaluation of the general hydrologic conditions at and near the waste-burial site suggested that low average annual precipitation and high average annual evapotranspiration would prevent water from percolating downward more than 1 or 2 feet below land surface. This assumption, however, did not consider the extreme annual and seasonal variations in a desert climate. During 1985-92, annual precipitation measured at the USGS study site ranged from 0.55 to 6.51 inches and monthly precipitation ranged from 0 to 2.34 inches. Monthly average temperature ranged from 38 to 92 degrees Fahrenheit. Most of the precipitation falls during the cool winter months when evaporative demands are low (fig. 3). Initial water-balance modeling by the USGS demonstrated that, under particular climate and soil-moisture conditions, tl potential for deep percolation does exist, in spite of high annual evaporative demands (Nichols, 1987).

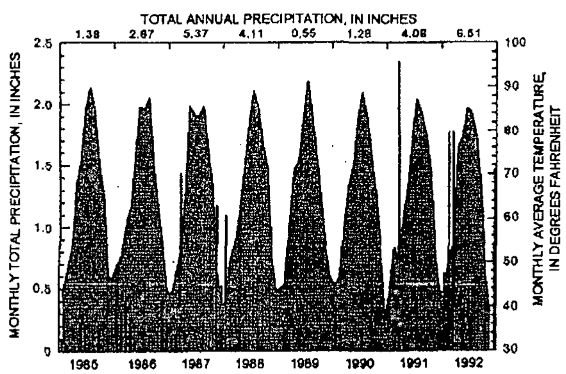

Figure 3. Annual and monthly total precipitation and monthly average temperature measured at U.S. Geological Survey field laboratory during 1985-92.

Field investigations to define the rates and directions of water movement through the deep unsaturated zone beneath undisturbed, vegetated area began in the early 1980's and coı tinue today. A study of chloride concentrations in the unsatu ated zone indicates that deep percolation of water was limite to the upper 30 feet during the past 16,000 to 33,000 years (Prudic, 1994a). To monitor present-day flow processes, an instrument shaft was installed that allows access for operatio of electronic devices to a depth of 45 feet (fig. 4; Fischer, 1992). Additional instrumentation has been installed to study flow processes throughout the unsaturated zone (Prudic, in press). Meteorological data are collected by an automated weather station (Wood and Andraski, 1995).

Water movement in the unsaturated zone is complex. Several variables—water content, water potential, humidity, and temperature—must be monitored to define rates and

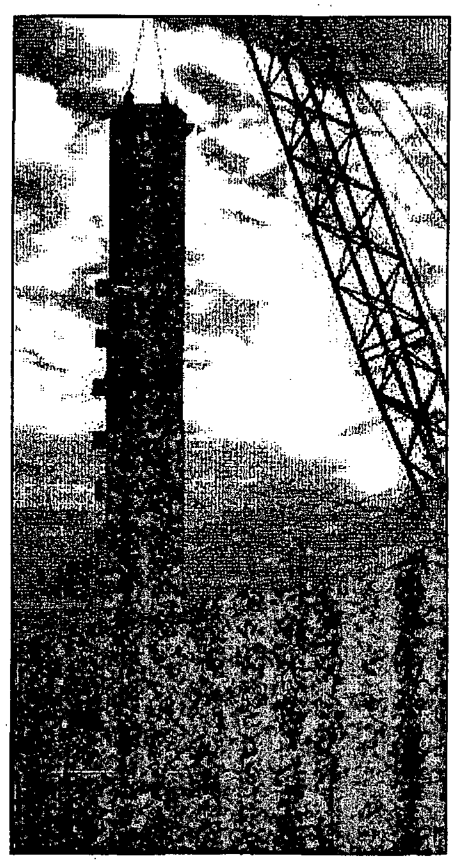

Figure 4. Installation of vertical shaft used for soil-moisture monitoring in upper 45 feet of unsaturated zone beneath undisturbed, vegetated area. Photograph by David S. Morgan, U.S. Geological Survey, August 1983.